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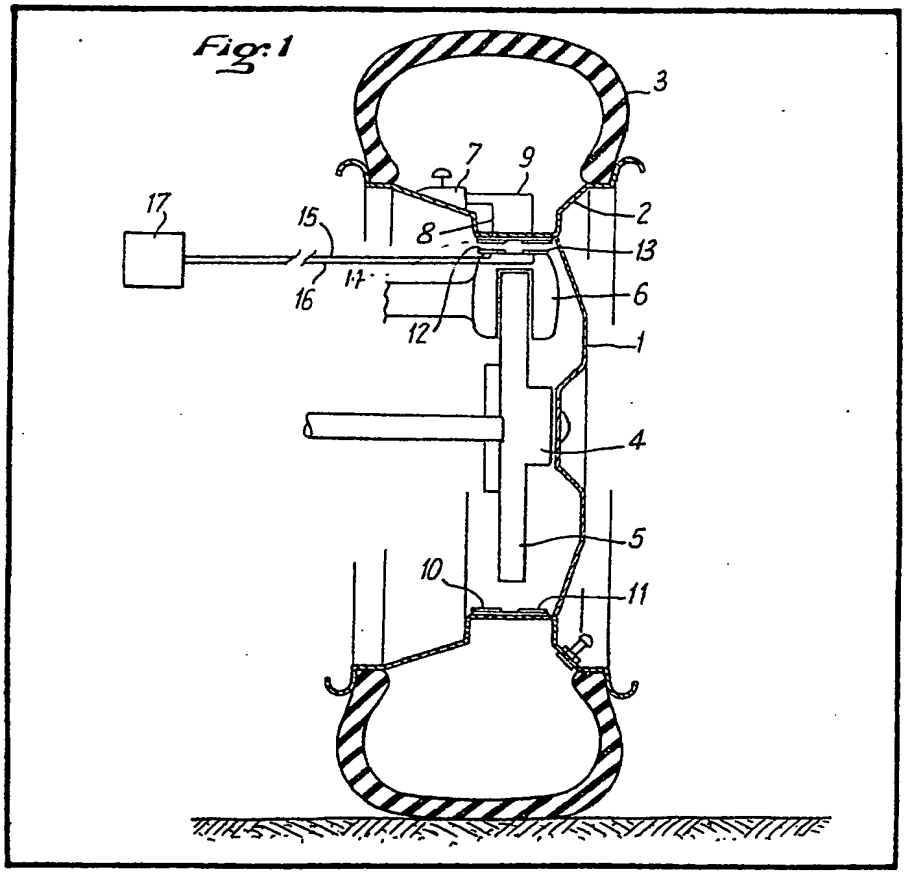
(54) **Measuring a parameter of a pneumatic tyre on a motor vehicle**

(57) The device comprises a unit 7 located inside a pneumatic tyre 3 and comprising a pressure sensor eg a piezoelectric sensor and/or a temperature sensor such as a thermistor, and connected to two capacitor plates 10, 11 located on the inner side of the wheel rim 2. The plates 10, 11 form with corresponding plates 12, 13 carried by a brake caliper device, two capacitors which are connected in a differential coupling mode to utilization means 17. The unit 7 is fed by an integrated lithium battery and transmits its information by an F.S.K. coding. Several tyres can be monitored by multiplexing from a central processor unit.



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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

Fig: 1

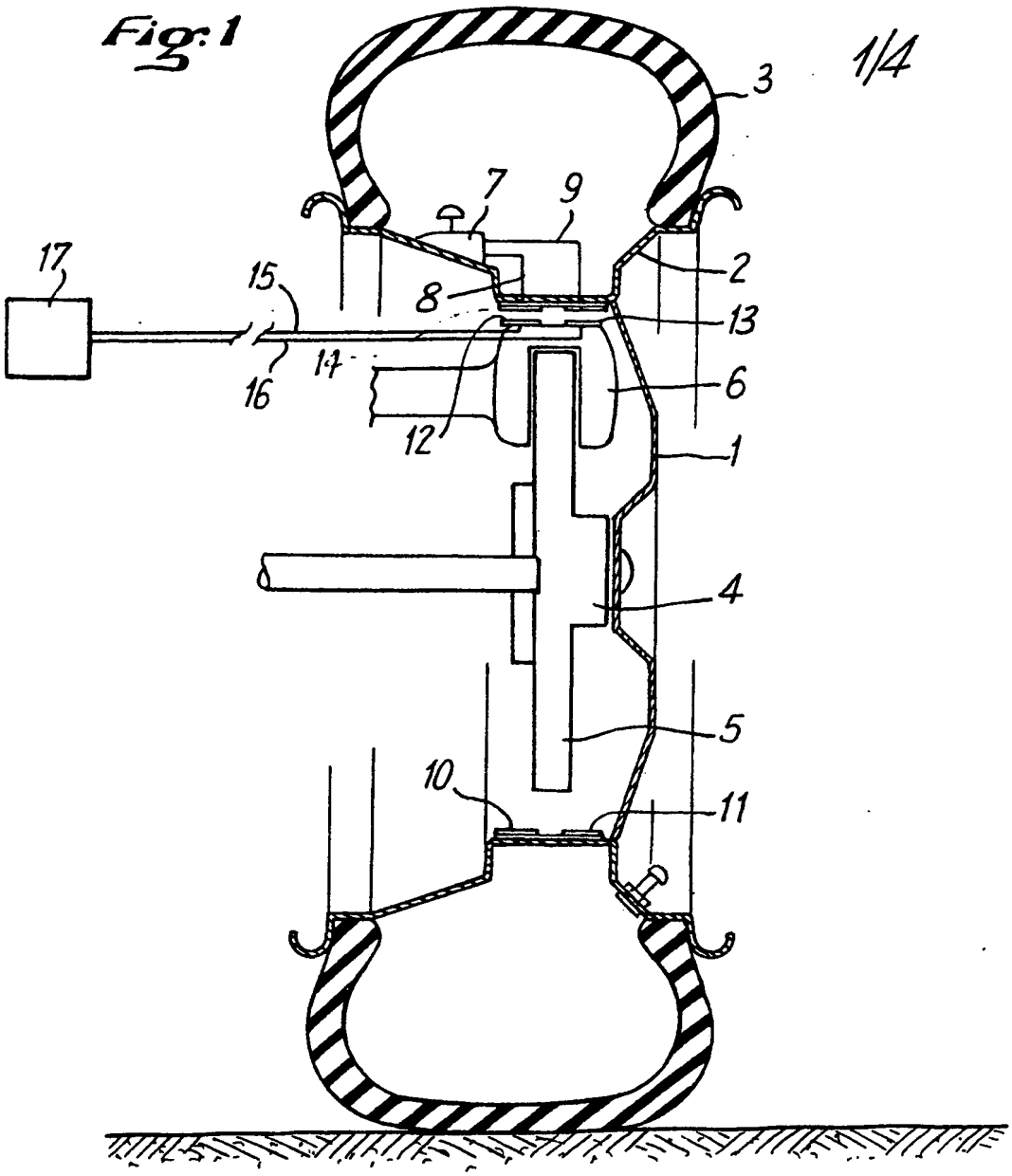


Fig: 2

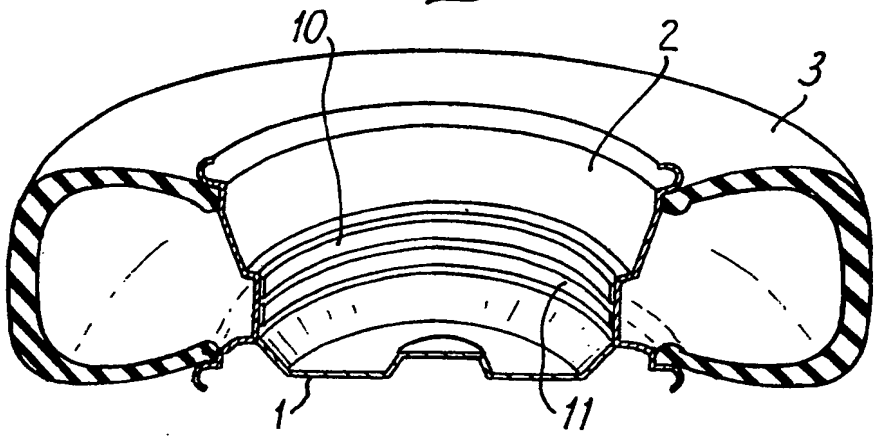


Fig: 3

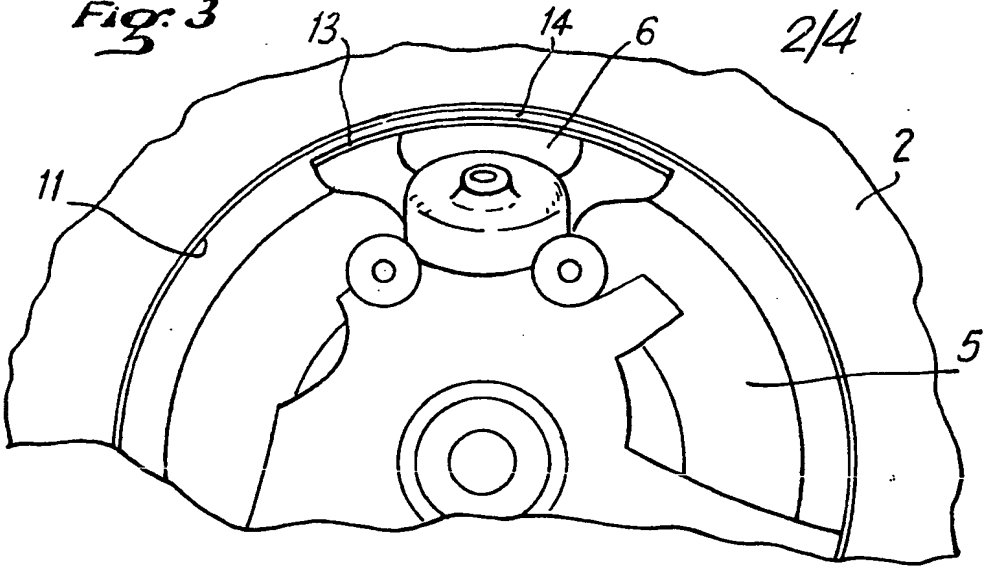


Fig: 4

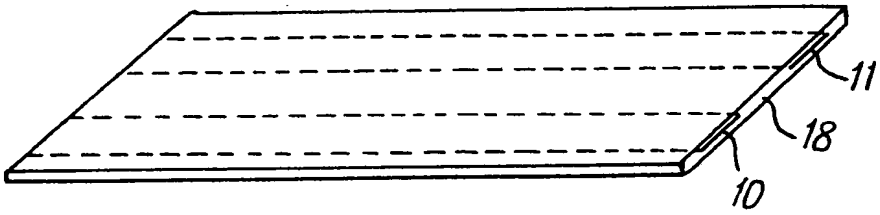
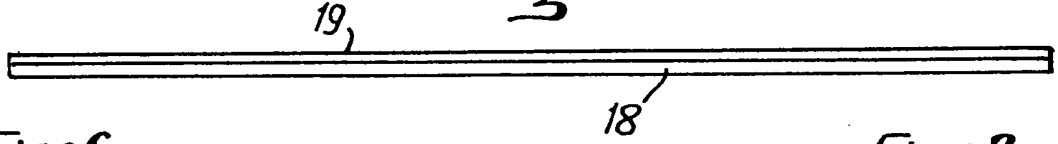


Fig: 5



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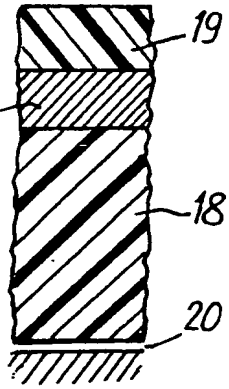

Fig: 8

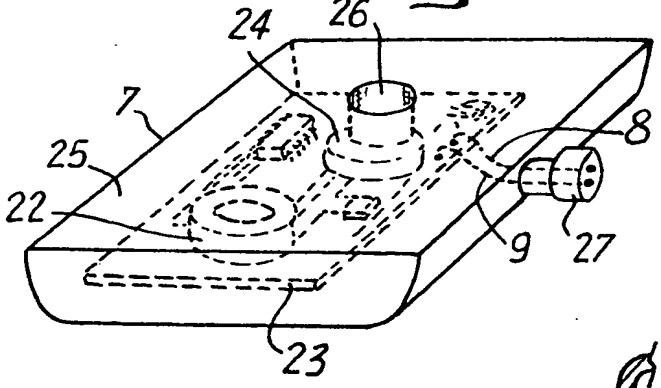

Fig: 9

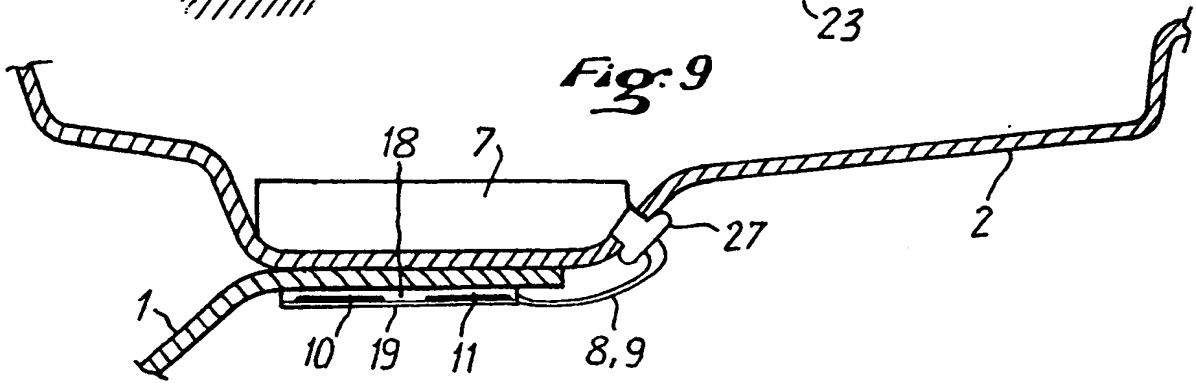

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Fig: 7

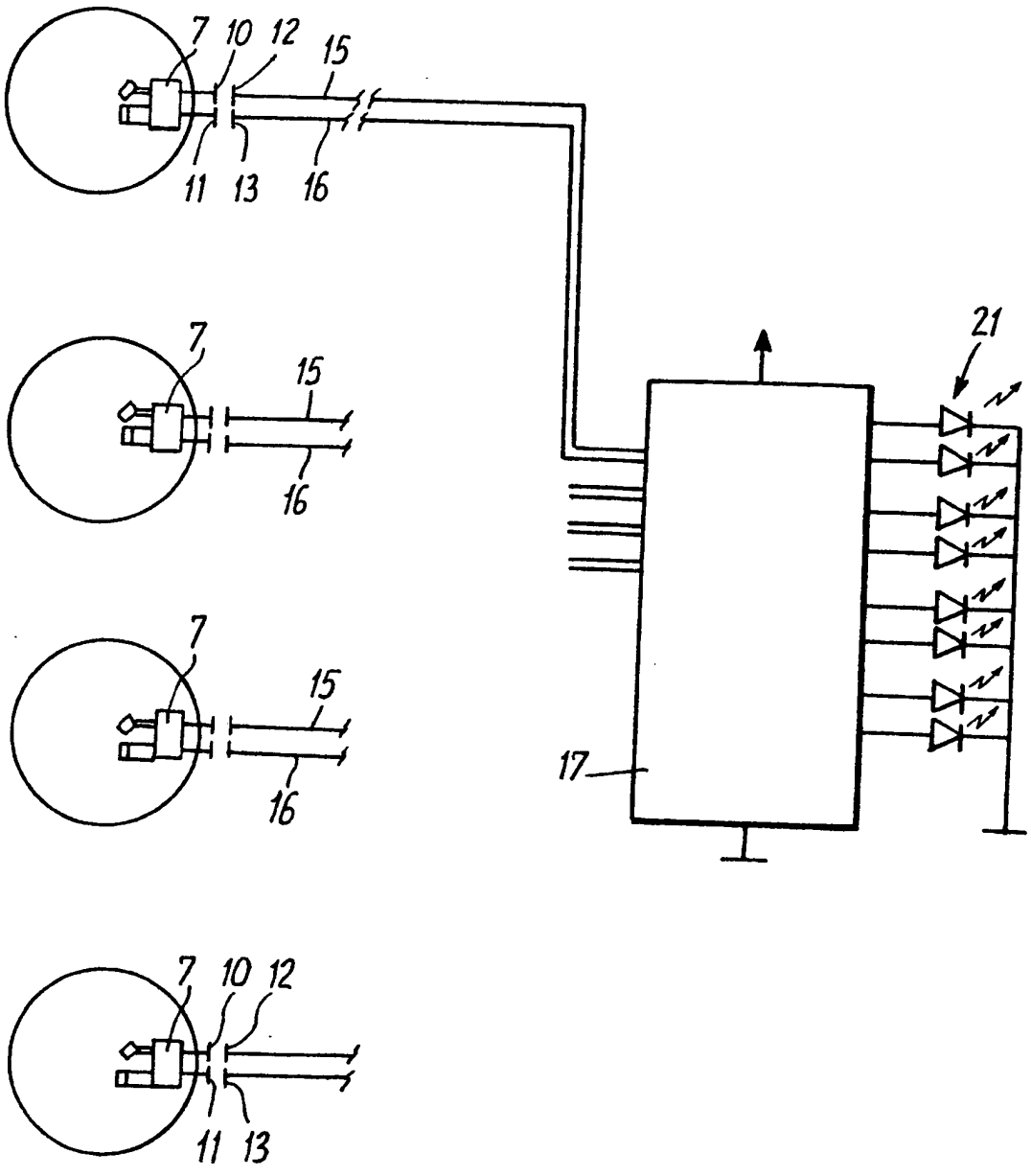

Fig:10

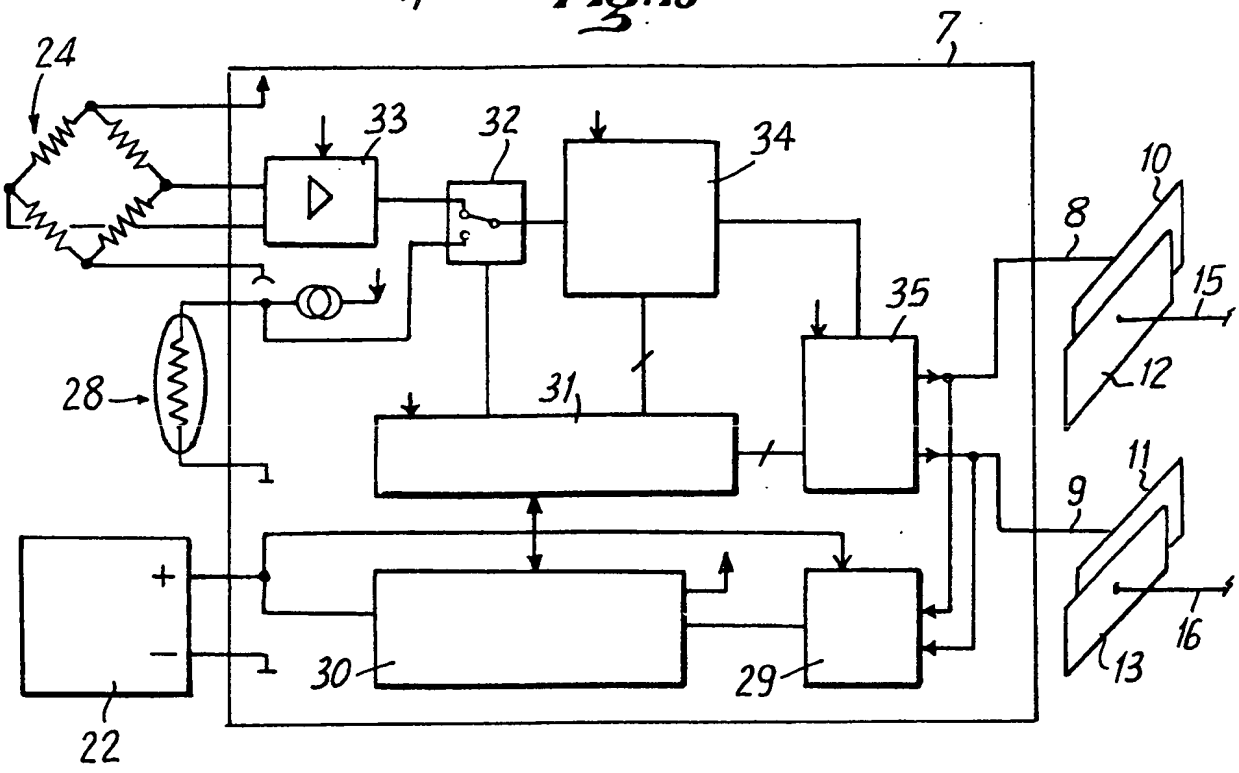
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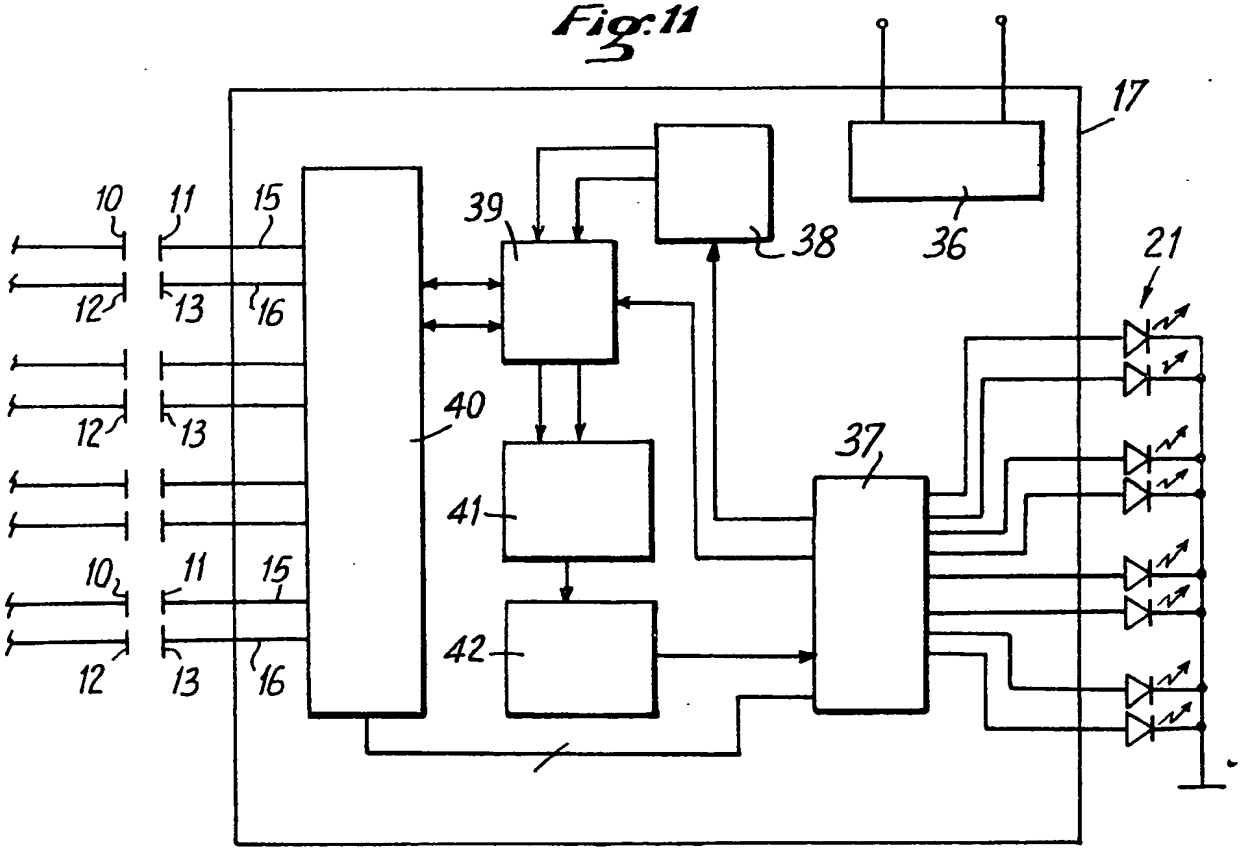
Fig:11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SPECIFICATION

Device for measuring a parameter in a pneumatic tyre on a wheel of in particular a motor vehicle

The present invention relates to a device for measuring a parameter such as, for example, a pressure and/or a temperature inside a pneumatic tyre carried by a wheel, said device being in particular applicable to the measurement of the pressure or the temperature inside a pneumatic tyre on one or more wheels of a motor vehicle such as, for example, a car or a heavy truck.

A number of devices have already been proposed for giving an indication concerning the value of a parameter such as, for example, the pressure, in respect of a rotary element or a wheel.

Most of these devices can only give an indication limited to a definite value of the parameter which closes an electric contact, the reading of the corresponding information being effected upon each rotation of the wheel at the moment of the angular coincidence between the element carried by the wheel and a fixed corresponding element. Apart from the inability to effect a measurement in a wide range of values, these devices are limited in their utilization due to the fact that when the rotary element stops in a random position, it is impossible for them to effect the measurement or transmit a measurement which has been effected. These devices, which employ an electro-magnetic coupling between the element carried by the wheel and the fixed corresponding element, are moreover in no way suitable for utilization in the field of current motor vehicles, since they require the presence, both on the wheel and in facing relation to the wheel on a non-rotating part of the vehicle, of electro-magnetic elements which are in practice incompatible with the requirements of simplicity and sturdiness associated with the replacement or removal on the part of unqualified personnel or the general public.

It has already been proposed to mount on a wheel carrying a pneumatic tyre a radio transmitter which cooperates with a receiver mounted on a non-rotating part of the vehicle. Such devices may possibly operate even upon the stoppage of the wheel in a random position. However, their use cannot be generalized owing to the fact that regulations in force would oppose the overcrowding of the hertzian waves produced by the presence of these devices on the many vehicles which would mutually scramble their information.

It has also already been proposed to achieve between two mechanical parts rotatable relative to each other, a transmission by a capacitive coupling employing two capacitors whose plates are respectively carried by the two facing mechanical parts so as to ensure, in one direction, the transmission of an electric energy from a frequency generator and remote control instructions by modulation of the frequency of the generator and, in the other direction, transmission of items of information coming from the measuring circuits which transmit at a frequency very much higher than the frequency of the power generator. However, such a device has various drawbacks. In particular, the mode of operating and the extremely different values of the frequencies employed, require that the capacitors have plates of large area and spaced apart at an extremely small distance, of the order of a millimetre. Such a device is in no way adapted to the transmission of signals between a wheel having a pneumatic tyre of a vehicle and a fixed part of the vehicle, bearing in mind the difficult environment, many possibly present parasitic effects and the requirements of simplicity and avoidance of space consumption, owing to the fact that the removal, replacement of the wheel or various interventions in this respect are carried out by persons who have little or no qualifications.

It has also already been proposed (U.S. patent No. 4 072 926) to dispose in a vehicle pneumatic tyre an electric switch responsive to pressure and located between two movable plates of a capacitive coupling which are disposed in front of two fixed plates connected to an electric generator and an impedance measuring circuit which is responsive to the variation in the impedance of the coupling when the switch is closed. This device only transmits off-on indications and is particularly sensitive to parasitic effects.

An object of the present invention is to overcome these drawbacks and to provide a device for measuring at least one parameter, such as for example the pressure and the temperature, in a wheel provided with a pneumatic tyre and in particular a motor vehicle wheel, whereby it is possible to detect the variable parameters in the region of or in the tyre, to transmit directly or possibly upon demand, the value or values of the parameters detected to a non-rotating structure of the vehicle and to utilize the information thus obtained, in a reliable manner.

Another object of the invention is to provide such a device which is capable of being employed in motor vehicles without requiring a real modification or transformation of the wheels and structures existing on the vehicle.

A further object of the invention is to provide such a device which consumes, practically no space in the region of the wheel and in the mounting of the device, so that it is possible to mount, remove or repair the wheels and the neighbouring structures, in particular the brakes, without requiring any intervention as concerns the device itself, persons having no qualifications being capable of effecting these operations as in the past.

Another object of the invention is to provide such a device which is capable of operating in very different environments, capable of being adapted to wheels and vehicles of completely different types and capable of accommodating extremely large variations in the clearances, spacing and tolerances of the mechanical parts

concerned, such as wheels, component elements, brakes, hubs, stub-axles, etc.

A further object of the invention is to provide such a device which, while being adaptable to completely different types of vehicles, is of a reduced price.

Another object of the invention is to provide such a device which requires no maintenance during an extremely long period.

The invention provides a device for measuring at least one parameter, such as in particular the pressure or the temperature, in respect of a pneumatic tyre of a wheel, in particular a motor vehicle wheel, said wheel being rotatable about an element defining an axis carried by a fixed structure, i.e. a non-rotating structure, in which the wheel comprises, in the pneumatic tyre or in the region of the tyre, at least one sensor for said parameter with an associated electronic circuit, and the structure carries utilization means responsive to the signals generated in said circuit, coupling means for transmitting said signals from the sensor circuit to said utilization means carried by the fixed structure, characterized in that the coupling means comprise two preferably identical capacitors each including two capacitor plates, one of the plates of the two capacitors being fixed to the wheel and the other plate being fixed, in facing relation, on the fixed structure so that the corresponding wheel plate passes in front thereof, the capacitors being connected with the sensor circuit and the utilization means in a differential transmission mode.

The two wheel capacitor plates are preferably fixed to the centripetal side of a wheel rim, the structure capacitor plates being fixed in facing relation on the fixed structure. In a particularly advantageous manner, at least one of the plates of each capacitor extends along an entire circumference so that a part of this plate is always disposed in front of the second plate of the capacitor. Particularly advantageously, the plate extending throughout a circumference is fixed on the wheel rim. In an arrangement on motor vehicles, a particularly advantageous feature of the invention resides in the mounting of a plate of each capacitor on the wheel rim and the mounting of the other plate of each capacitor on the periphery, close to the rim, of the device carrying the brake shoes of the disc or drum brake.

Preferably, the distance between the two plates of the same capacitor is between a few millimetres and a centimetre, it being possible to vary this spacing without introducing disturbances in the transmission.

According to a particularly advantageous manner of carrying out the invention, the coding and the transmission of the signals are effected in accordance with an F.S.K. modulation, i.e. a modulation of the type in which the coding is by frequency variation, so that, owing to the differential transmission mode, the information from the sensor or sensors is transmitted in a digital form which may be easily utilized by digital utilization means.

However, if desired, it is also possible to employ a frequency modulation coding or any other coding permitting a proportional transmission of the information, i.e. a large number of different values of the physical parameter or parameters, such as the pressure or temperature, in a wide and preferably continuous range of measurements.

According to a particularly advantageous feature of the invention, the electronic circuit associated with the sensor or sensors has a source of electric energy connected to the circuit or carried by the rotating wheel, such as a battery having a long life, for example of the lithium type.

Preferably, the capacitor plates are formed by metal bands integrated into a laminated insulating structure so as to include a thin supporting insulating band one side of which is adapted to be applied against the moving part, such as the wheel rim, or against the fixed structure whereas the other side carries one or preferably two parallel metal bands, the band or bands and the apparent part of this last-mentioned side of the insulating band being covered with a second insulating band preferably thinner than the first-mentioned insulating band. It is thus possible to manufacture industrially and continuously a complex band which is cut to the desired lengths so as to form the desired capacitor plates. According to the embodiment already described, it is preferred to cut each time a length corresponding to the perimeter of the inner or centripetal side of a wheel rim and a second shorter length adapted to be applied to the periphery which is facing the rim and pertains to a braking device, but, by way of a modification, it is also possible to cut lengths intended to extend through the entire circumference both of the wheel and the fixed part outside the latter, or lengths corresponding to only partial arcs of said circumferences, in which case a transmission in the state stopped in a random angular position is not however ensured.

Preferably, the sensor or sensors and the associated electronic circuit are constructed in the form of a unit embedded in an insulating resin, the circuit being arranged in the C/MOS way ensuring a low consumption. The unit advantageously comprises a pressure sensor, for example of the piezo-electric or quartz type, or of a capacitive variation type or resistive gauge type directly communicating with the atmosphere in the pneumatic tyre, while the integrated circuit of the C/MOS type may integrate the temperature sensing means capable of delivering signals proportional to the temperature.

By way of a modification, the temperature sensor may be a conventional thermistor suitably inserted in the circuit or connected to the latter.

The fixing of the capacitor plates, for example in the form of a laminated or layered structure as described hereinbefore, is preferably achieved by adhesion to the corresponding supports such as a

wheel rim and brake structure, these plates forming merely a practically negligible extra thickness on the confronting surfaces and resulting in no modification of their appearance or shape.

The capacitive connection between the sensor or sensors with the associated circuit and the utilization means may be mono-directional, the signals then being transmitted solely from the plate connected to said circuit to the second plates connected to the utilization means. However, preferably the connection may be bi-directional, signals such as command signals being possibly then also sent from the utilization means from said second plates which are connected thereto to the first plates connected to the circuit and to the sensor.

In the latter case, the coding of the instructions thus sent by the utilization means to the wheel circuit is preferably of the F.S.K. type and the frequencies employed may be in the neighbourhood of or even identical to the frequencies employed in the other direction for the transmission of information corresponding to the measurements effected by the sensor or sensors.

Particularly advantageously, the frequency range used is between 50 and 1000 kHz and preferably between 100 and 400 kHz.

The utilisation means, which may advantageously include a microprocessor and various display means such as LEDs for displaying the results, are preferably provided for utilizing the parameters coming from a plurality of sensors mounted in different wheels of a vehicle. Preferably, the information corresponding to the measurements, for example of temperature and pressure, are transmitted in succession from the various wheels by time-division multiplexing, the piloting being effected from the utilization means. These means decode the information transmitted and process it, such as, for example the processing of the calculations, the deviations and the exceeding of threshold values, gradients of parameters with respect to time, co-relations between parameters of different wheels, alarm signals, etc.

Further features and advantages of the invention will be apparent from the following description which is given by way of a non-limiting example with reference to the accompanying drawings in which:

Figure 1 is a diagrammatic sectional view of a wheel with a device according to the invention.

Figure 2 is a perspective view of a part of this wheel.

Figure 3 is an elevational view of a part of this wheel.

Figure 4 is a perspective view of an assembly of two capacitor plates in a laminated system.

Figure 5 is an elevational view of the element of Figure 4.

Figure 6 is a cross-sectional view of the element of Figure 4.

Figure 7 is a diagrammatic view of the arrangement of a device for a plurality of wheels.

Figure 8 is a diagrammatic perspective view of a unit comprising sensors and their circuit.

Figure 9 is a diagrammatic view of a unit comprising sensors and circuit according to Figure 8 mounted on the centrifugal side of a wheel rim.

Figure 10 is an electric block diagram of the unit comprising sensors and the associated circuit.

Figure 11 is a block diagram of the utilization means.

Reference will be made to Figures 1 to 3 first of all.

The wheel on which the device must be mounted is a motor vehicle wheel. It comprises a disc-shaped web 1 carrying a rim 2 of usual shape supporting a pneumatic tube-less tyre 3. The wheel web 1 is adapted to be fixed in an easily detachable manner, as is well known, to a hub part 4 carrying the disc 5 cooperating with a brake device 6 having calipers of a conventional type. This brake device having calipers 6 is mounted on a fixed structure of the vehicle, i.e. a non-rotating structure.

Disposed inside the volume of air under pressure defined by the tyre 3 against the centrifugal side of the rim 2, is a unit 7 whose structure will be described in detail hereinafter and which includes one or a plurality of sensors such as a pressure and/or temperature sensor responsive to the pressure and/or the temperature inside the tyre. This sensor is connected by conductors 8, 9, diagrammatically represented to two rim capacitor plates 10, 11 each of which comprises a metal band enclosed in an insulating material as will be explained in detail hereinafter. Each of the capacitor plate bands 10, 11 extends on the centripetal side of the rim 2 throughout the circumference thus offered. When the wheel rotates, the two parallel plates 10, 11 thus pass in front of two fixed capacitor plates 12, 13 which are insulated in the same manner and mounted on the surface in the shape of a sector of a cylinder of the braking device 6 which faces the central part of the rim 2 on which the rim capacitor plates are secured. In this way, the rim plate 10 passes exactly above the fixed plate 12 and the rim plate 11 passes exactly above the fixed plate 13, the rim plates and the fixed plates being respectively separated by a free gap 14 of the order of 5 mm. Conductors 15, 16 respectively connected to the plates 12 and 13 lead to utilization means diagrammatically shown at 17, the latter being supported by the body of the vehicle. Preferably, the connection thus formed by the conductors 15 and 16 includes a connector (not shown) so as to permit an easy removal of the device 6 which carries the plates 12 and 13.

It will be understood that, in this way, the values of the physical parameters measured by the sensor or sensors of the unit 7, suitably shaped, as the case may be, by the associated

circuit, form electric signals transmitted by the conductors 8 and 9 to the plates 10 and 11, and by capacitive coupling, to the plates 12 and 13 and then, by the conductors 15 and 16, to the utilization means 17. The differential capacitive coupling is so arranged in accordance with the invention, to transmit the information in F.S.K. at a frequency between preferably 100 and 400 kHz.

Thus it is possible, without fearing the parasitic effects coming from additional capacities necessarily present owing to the existence of different neighbouring metallic parts, or other electric disturbances which are always possible, to transmit to the utilization means 17 the desired signals corresponding to the parameter measurements in continuous or discontinuous wide ranges of values.

In the illustrated embodiment, the various capacitor plates 10, 11, 12, 13 are disposed on geometrically cylindrical surfaces. However, it will be understood that it would also be possible, in accordance with the geometries of the neighbouring wheel parts and fixed parts, to dispose the fixed and moving capacitor plate assemblies on other surfaces of the revolution such as, for example, cones or discs. Further, owing to the invention, rather large variations can be tolerated in the value of the gap 14 between the fixed plates and the corresponding rotating plates. Thus, it is possible not only to absorb the tolerances pertaining to the diameters or shapes of the rims but also to mount for example one of the plates, such as the plates 12 and 13, on a fixed (non-rotating) support which, in contrast to the device 6, would be spaced from the rim by a non-constant gap, provided that this gap remains mainly confined within a range of a few millimetres to about 10 millimetres. Also, lateral displacements are tolerated.

Reference will now be made to Figures 4 to 6.

In order to construct the assemblies of two capacitor plates described hereinbefore, such as the plate assembly 10, 11 and the assembly 12, 13, there may be advantageously employed a sheet or band of insulating synthetic material, such as for example an epoxy glass or a polyimide. This support 18 receives two parallel metal bands, for example 10 and 11, having a thickness of the order of 50 μm, after which a new sheet of insulating material 19, such as an epoxy glass or a polyimide, is applied on the assembly in such manner that the metal parts 10, 11 are completely enveloped. Outside the plates 10, 11 themselves, the insulating sheets 18 come into contact so as to surround them.

Instead of employing metal bands to form the plates, a metallization may be formed on the synthetic or plastics material forming the insulator.

The laminated or layered assemblies of capacitor plates thus obtained may be manufactured continuously in a great length for subsequently cutting to the required length, for example the length required to extend round the entire centripetal side of the rim 2 and the length of the arc of a circle defined by the braking device 6.

The same manufacturing method may be employed under these conditions for the applications to very different vehicles.

It will be in particular understood that the capacitor plate assembly 12, 13 could also extend throughout the complete circumference instead of being limited to a sector and, if desired, the plate assembly 10, 11 may itself extend on only a sector of a circumference.

The electric connection between the conductors, such as 8, 9, and 15, 16, and the capacitor plates 10, 11, 12, 13 corresponding thereto may be achieved in various ways, for example after baring or drilling one of the insulating elements and preferably the support 18.

The assemblies thus formed are preferably secured by adhering them directly to the support by means of a thin coat of adhesive 20 uniting the support 18 to the metal part of the wheel such as the wheel web. The adhesive may advantageously be an epoxy adhesive.

Preferably, the width of the plates is between 5 and 10 mm, the total width of an assembly such as that shown in Figure 4 being then of the order of 20 to 30 mm.

With reference to Figure 7, there is shown a diagram in which the assemblies 7 of four wheels are electrically connected by time-division multiplexing to a single utilization device 17 which brings into action display means 21 such as LEDs.

Reference will now be made to Figures 8 to 10.

The unit 7 comprises a lithium battery 22, an integrated C/MOS circuit 23 and a piezo-electric pressure sensor 24. The unit is moulded in a block of resin 25 leaving a cavity 26 permitting the putting of the exterior in communication with the pressure sensor 24. The block 25 is shaped in such manner as to be adaptable in the part of the rim 2 which receives it and be secured in this part for example by adhesion. Preferably, the conductors 8, 9 which come from the board 23 lead to a connector 27 which is shaped in such manner as to pass through a hole drilled in the rim, the conductors then leading through the complementary part of the connector to the plates 10, 11.

The device may also include a thermistor 28 unless the electronic circuit itself is used for providing information corresponding to the temperature variation.

As can be seen more clearly in Figure 10, the circuit of the device 7 comprises a standby receiver 29 connected to the conductors 8 and 9 and which normally is the sole element fed by the battery 22. When it is commanded by a signal from the utilization means 7, the standby receiver actuates a controlled supply 30 which at that moment feeds the rest of the integrated circuit. A sequencing logic circuit 31 starts up, in succession and through the switching means 32,

a reading of the pressure sensor 24, for example of the gauge type implanted in silicon, the signal being calibrated by the calibrator 33, then a reading of the temperature sensor 28. These readings of analog values are converted into digital words by the analog-to-digital converter 34. The digital words code an F.S.K. modulator 35 loaded in the differential mode by the capacitances of the plates, namely 10, 12 and 11, 13. Thereafter, the integrated circuit is set at rest by the controlled supply 30.

Reference will now be made to Figure 11. The utilization means 17 to which lead the various conductors 15, 16 coming from the various groups of two capacitors pertaining to the four wheels, comprise a suitable supply 36 which utilizes for example the battery of the vehicle and which, when it is connected, feeds a microprocessor 37 which starts the following sequencing:

A code generator 38 generates a code actuating the electronic circuit of the unit 7 which is successively switched by multiplexers 39, 40 to the conductors 15, 16, and, through capacitive coupling, to the means 7 pertaining to the various wheels. As seen hereinbefore, in return, all of the wheels generate a response which is demultiplexed by 40 and then 39, calibrated by a calibration means 41, then decoded by 42 so as to be processed by the microprocessor 37. In accordance with its specific program, the latter forms items of information which are presented to the display means such as the LEDs 21.

The latter are preferably so arranged as to enable a driver of a vehicle to read off separately, for each wheel, the temperature and pressure values prevailing inside the pneumatic tyre.

As soon as the supply 36 is ceased to be actuated, the device no longer consumes any electric energy, except for the very small amount of energy required to maintain the receiver 29 in its standby condition, this energy being obtained from the battery 22.

Although the invention has been described with respect to a particular embodiment, it must be understood that it is in no way limited thereto and that various modifications of design or material may be made therein without departing from the scope of the invention as defined in the claims.

Claims

1. A device for measuring at least one parameter, such as in particular the pressure or the temperature, in respect of a pneumatic tyre of a wheel, in particular of a motor vehicle wheel, said wheel being rotatable about an element defining an axis carried by a fixed structure, in which the wheel comprises, in the pneumatic tyre or in the region of the tyre, at least one sensor with an associated electronic circuit and the structure carries utilization means responsive to the signals generated in said circuit, coupling means permitting the transmission of said signals from the sensor circuit to said utilization means carried by the fixed structure, characterized in that the coupling means comprise two capacitors each including two capacitor plates, one of the plates of the two capacitors being fixed on the wheel and the other plate being fixed in facing relation on the fixed structure so that the corresponding wheel plate passes in front thereof, the capacitors being connected with the sensor circuit and the utilization means in a differential transmission mode.

2. A device according to claim 1, wherein the two capacitors have equal values.

3. A device according to claim 1 or 2, wherein the two wheel capacitor plates are fixed on the centripetal side of a wheel rim.

4. A device according to claim 3, wherein the fixed plates are fixed on the peripheral face, close to the rim, of a brake caliper device.

5. A device according to any one of the claims 1 to 4, wherein the wheel capacitor plates and/or the fixed capacitor plates extend through an entire circumference.

6. A device according to any one of the claims 1 to 5, wherein the wheel plates and the fixed plates are spaced apart between a few millimetres and a centimetre.

7. A device according to any one of the claims 1 to 6, wherein the coding and the transmission of the signals by the circuit are effected according to an F.S.K. modulation.

8. A device according to any one of the claims 1 to 7, wherein the circuit associated with the sensor comprises its own source of electricity, for example a long-life battery.

9. A device according to any one of the claims 1 to 8, wherein the plates of the capacitors are constituted by a laminated structure of bands including an insulating support band one of the sides of which is adapted to be fixed, in particular by adhesion, to the wheel or the fixed structure, whereas the other side supports at least one plate in the form of a band, said other side and said plate being covered with a covering band.

10. A device according to any one of the claims 1 to 9, wherein the frequency of the transmitted signals is between 50 and 1,000 kHz and in particular between 100 and 400 kHz.

11. A device according to any of the claims 1 to 10, wherein the circuit associated with the sensor is of the C/MOS type.

12. A device according to any of the claims 1 to 11, wherein said circuit and the sensor or sensors are enclosed in a resin block, an orifice being provided for putting a pressure sensor in communication with the atmosphere inside the pneumatic tyre, and a connecting device being provided for the electric connection with the rim capacitor plates.

13. A device according to any one of the claims 1 to 12, wherein the circuit associated with the sensor is responsive to command signals from the utilization means.

14. A device according to claim 13, wherein said associated circuit comprises a standby receiver connected to the rim capacitor plates, a

supply battery, a controlled supply actuated by the standby circuit, a sequencing logic circuit piloting switching means permitting the successive reading of a pressure sensor and a temperature sensor, an analog-to-digital converter receiving said reading and an F.S.K. modulator loaded in a differential mode by said capacitor plates.

15. A device according to any one of the claims 1 to 14, wherein the utilization means comprise a supply which pilots a microprocessor controlling an initiating code generator to which the circuit associated with the sensor is responsive, multiplexing means connected to the fixed plates of a plurality of capacitors corresponding to a plurality of wheels, a calibration element receiving the response demultiplexed by the multiplexers, a decoder returning the information to the microprocessor, and display means.

16. A device for measuring a parameter in a pneumatic tyre on a wheel substantially as hereinbefore described with reference to the accompanying drawings.

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